smooth transition from one mode to another. In an embodiment of the present invention, during transition from stopped mode to balancing mode, there is a linear ramp from the stopped to the balancing mode applied over a short time interval, preferably in the range of 800 ms. In an embodiment of the present invention, Stopped mode has an additional torque calculated that is added to each motor in proportion to its speed as described above.

[0080] As described above, all control circuitry may be contained on a single printed circuit board **690** as shown in FIG. **6**. In an embodiment of the present invention, the control circuitry comprises:

- **[0081]** a 16-bit microcontroller/DSP;
- **[0082]** a 6-axis motion sensor (gyroscope and accelerometer). In an embodiment, the yaw and roll axes may be unused and powered down by software;
- **[0083]** 4 load cell inputs with adjustable null offsets (load sensors);
- **[0084]** 6 H-bridge power drivers, 3 for each motor;
- **[0085]** A current sensor on the lower leg of each H-bridge;
- **[0086]** A current sensor on the return to the battery;
- **[0087]** 2 motor position sensor inputs;
- **[0088]** RGB LEDs;
- **[0089]** LED strip driver output; and
- **[0090]** Battery, charge input and motor phase voltage monitors.

[0091] In some embodiments of the present invention, the motor control is accomplished in the normal way for sensored brushless motors. The phase of the 3 H-bridges is determined by the sensor input. The current/torque is measured and controlled by a feedback loop that modulates the pulse width modulation (PWM) to maintain the current set point. In a preferred embodiment, the modulation scheme may be Space Vector Modulation.

[0092] In an embodiment of the present invention, the motor torque is limited by limiting the maximum current to each motor to one that the motors can safely handle. The total motor torque is also limited such that the battery current does not exceed the permitted maximum. When torque is limited, active balancing control cannot be maintained if any additional lean occurs in the direction of motion. In that case, the rider may start to fall forward and may fall off or need to jump from the vehicle before falling. In some embodiments of the present invention, the vehicle may have temperature sensors in the motors and preferably also on the motor driver transistors. The maximum motor current allowed is reduced as these temperatures rise above selected thresholds.

[0093] In an embodiment of the present invention, an operational alarm indicates a potential balancing issue. Preferably, the operational alarm is triggered when any of the following conditions are met:

- **[0094]** Average PWM is above 85% of its maximum (this is equivalent to the voltage being applied to the motors being above 85% of the battery voltage, which can occur at high vehicle speeds or under heavy vehicle loads);
- **[0095]** Motor current is above 90% of its maximum for more than 0.5 seconds (this may occur under heavy vehicle load at lower speeds);
- **[0096]** Motor driver transistor temperature is above a predefined threshold (e.g., 55 degrees Celsius); and
- **[0097]** Motor winding temperature is above a predefined threshold (e.g., 66 degrees Celsius).

[0098] Additional embodiments of the present invention may include enhanced features. For example, the single platform housing of the vehicle may include a Bluetooth or other wireless-enabled audio speaker system. The housing may also include additional integrated lighting that may be modulated by sound from the speaker system or specific motions of the vehicle. Preferably, any Bluetooth or other data connection integrated in the vehicle may include control circuitry, software or firmware to allow user notification of alarms from the vehicle, or control of the vehicle speakers, movement, lights, etc. by a mobile app accessible via smart phone, tablet or other personal computing device. For example, one embodiment of the present invention may include a mobile application accessible via smart phone, tablet or other portable personal computing device that would allow a user to steer the vehicle remotely by activating portions of a touchscreen or activating gyroscope or accelerometer sensors on the smart phone to power on/off, speed up, slow down, turn, or tilt the vehicle. In one embodiment, a remote control joystick or other input device could also enable a user to remotely control steering, tilt, acceleration, deceleration and power on/off functions of the vehicle.

[0099] While the present invention has been particularly described with respect to the illustrated embodiments, it will be appreciated that various alterations, modifications and adaptations may be made based on the present disclosure, and are intended to be within the scope of the present invention. While the invention has been described in connection with what are considered to be the most practical and preferred embodiments, it is to be understood that the present invention is not limited to the disclosed embodiments, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the scope of the appended claims.

1. A self-balancing transport vehicle, comprising:

a support platform housing comprising one or more inertial sensors operable to provide data indicating the pitch of the support platform, a first foot placement section and a second foot placement section;

a first wheel associated with the first foot placement section and a second wheel associated with the second foot placement section, the first and second wheels being spaced apart and substantially parallel to one another;

a first drive motor configured to drive the first wheel and a second drive motor configured to drive the second wheel;

at least one load sensor operable to provide first load data for the first foot placement section and at least one load sensor operable to provide second load data for the second foot placement section, wherein the first load data comprises a first front load data and a first rear load data of the first foot placement section and the second load data comprises a second front load data and a second rear load data of the second foot placement section; and

control circuitry connected to the first and second drive motors, and operable to transmit balancing torque signals to the first and second wheels for self-balancing the support platform housing in response to the pitch